

# Exercises and Complements for the Introduction to Physics II

## for Students

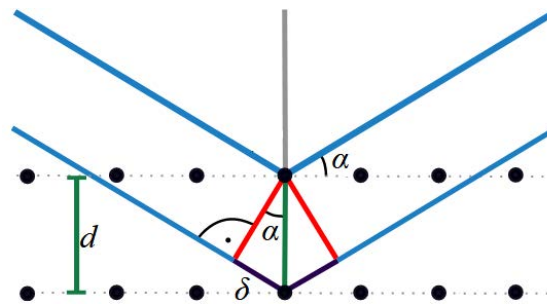
### of Biology, Pharmacy and Geoscience

Sheet 9 / 27.04.2022

### Solutions

#### Exercise 33.

The so-called Bragg condition is used to calculate the lattice plane spacing  $d$ , which can be derived in a similar way to the interference on thin layers (script p. 503-2).



The maxima in the measured spectrum occur when the maxima of the reflected light waves (at different planes) are superimposed. This happens e.g. at  $\alpha \approx 7.5^\circ$ . So here the path difference  $2\delta$  must correspond exactly to the wavelength  $\lambda$ :

$$2\delta = \lambda \quad \text{or} \quad \delta = \frac{\lambda}{2}$$

According to the sketch, the following applies between two levels:

$$\sin \alpha = \frac{\delta}{d}$$

Thus for the lattice plane spacing  $d$  in question, it follows:

$$d = \frac{\delta}{\sin \alpha} = \frac{\lambda}{2 \cdot \sin \alpha} = \frac{7.0 \cdot 10^{-11} \text{ m}}{2 \cdot \sin 7.5^\circ} = 2.7 \cdot 10^{-10} \text{ m}$$

**Exercise 34.**

(a) The following applies for the theoretical magnification (cf. p. 404-10):

$$\Gamma = \frac{s \cdot s_0}{f_1 \cdot f_2}$$

The following applies to the tube length  $s$ :

$$s = a - f_1 - f_2 = 0.168 \text{ m}$$

Hence it follows:

$$\Gamma = \frac{0.168 \text{ m} \cdot s_0}{f_1 \cdot f_2} = \frac{0.168 \text{ m} \cdot 0.25 \text{ m}}{0.012 \text{ m} \cdot 0.02 \text{ m}} = 175$$

(b) For the focal length of the eyepiece it follows:

$$\begin{aligned} \Gamma &= \frac{s \cdot s_0}{f_1 \cdot f_2} \\ \frac{\Gamma \cdot f_2}{s_0} &= \frac{a - f_1 - f_2}{f_1} \\ \frac{\Gamma \cdot f_2}{s_0} + 1 &= \frac{a - f_2}{f_1} \\ f_1 &= \frac{s_0(a - f_2)}{\Gamma \cdot f_2 + s_0} \\ f_1 &= \frac{0.25 \text{ m} \cdot (0.2 \text{ m} - 0.012 \text{ m})}{100 \cdot 0.012 \text{ m} + 0.25 \text{ m}} = 3.2 \text{ cm} \end{aligned}$$

(c) Accordingly, the following applies to magnification:

$$\Gamma = \frac{B}{G} = \frac{18.75 \text{ mm}}{2.5 \text{ mm}} = 7.5$$

For the focal length of the lens it follows analogously to (b):

$$f_2 = \frac{s_0(a - f_1)}{\Gamma \cdot f_1 + s_0} f_2 = \frac{0.25 \text{ m} \cdot (0.2 \text{ m} - 0.02 \text{ m})}{7.5 \cdot 0.02 \text{ m} + 0.25 \text{ m}} = 11.3 \text{ cm}$$

**Exercise 35.**

(a) See script 504-9.

$$d = \text{Lattice constant} = \frac{1}{1000} \text{ cm} = 1 \cdot 10^{-5} \text{ m}$$

Intensity maxima for the lattice with constant spacing  $d$ :

$$\sin \theta_m = m \frac{\lambda}{d} \quad \Rightarrow \quad \theta_1 = \arcsin \frac{\lambda}{d} = 3.73^\circ$$

(b) The largest value for  $m$  in the equation for the intensity maxima occurs when  $\sin \theta_m$  is maximal (i.e. = 1).

$$m_{max} = \frac{d}{\lambda} = \frac{1 \cdot 10^{-5} \text{ m}}{650 \text{ nm}} = 15.38 \quad \Rightarrow \quad \text{Maximum diffraction order} = 15$$

(c) The equation from (a) must be rearranged here for  $m = 1$ :

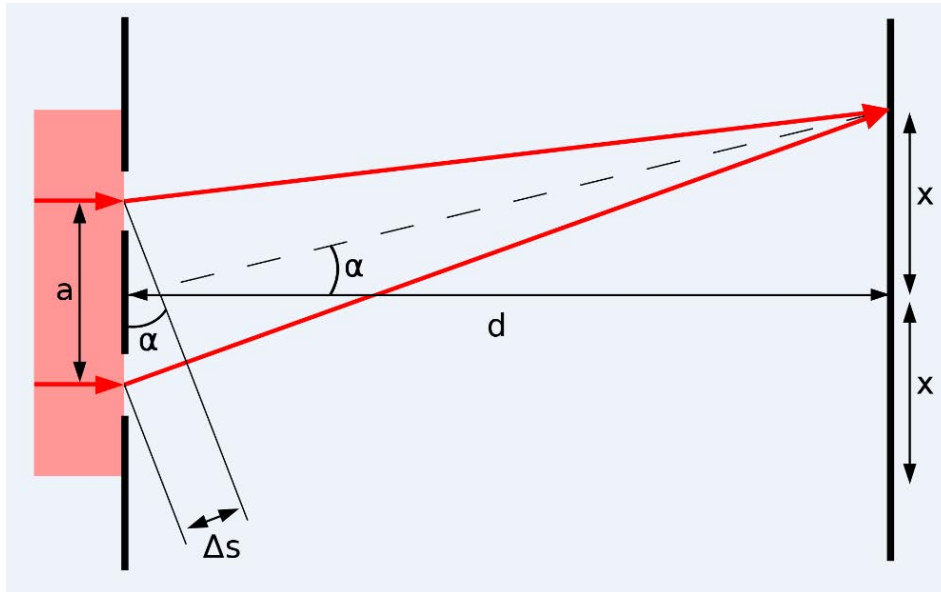
$$\lambda = d \cdot \sin \theta$$

So it follows:

$$\lambda_1 = 1 \cdot 10^{-5} \text{ m} \cdot \sin 2.46^\circ = 429.2 \text{ nm} \quad \text{und} \quad \lambda_2 = 1 \cdot 10^{-5} \text{ m} \cdot \sin 3.15^\circ = 549.5 \text{ nm}$$

### Exercise 36.

The following sketch shows all the important relationships:



For the gap distance, the following relationship can now be established using the path difference  $\Delta s$  and the angle  $\alpha$ :

$$\sin \alpha = \frac{\Delta s}{a} \quad \text{bzw.} \quad a = \frac{\Delta s}{\sin \alpha}$$

The following applies to the path difference at the 4th maximum:

$$\Delta s = 4 \cdot \lambda$$

Furthermore, the small angle approximation applies to the entire experimental setup:

$$\sin \alpha = \tan \alpha = \frac{x}{d}$$

Since the distance between the two 4th order maxima is  $2x = 26 \text{ mm}$ , it follows that  $x = 13 \text{ mm}$ . Hence for  $a$ :

$$a = \frac{\Delta s}{\sin \alpha} = \frac{4 \cdot \lambda \cdot d}{x} = \frac{4 \cdot 633 \text{ nm} \cdot 1700 \text{ mm}}{13 \text{ mm}} = 331.1 \mu\text{m}$$